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ABSTRACT

This module is the ninth of 10 modules in the competency-based electronics series. Introductory materials include a listing of competencies addressed in the module, a parts/equipment list, and a cross reference table of instructional materials. Five instructional units cover: fiber optic cable; optical coupler; lasers and masers; optical displays; and optical encoders. Each unit includes some or all of the following components: performance objectives; information sheets; transparency masters; handouts; assignment sheets; job sheets; and unit test with answer key. Special instructions are included in the notes to the instructor section near the beginning of each unit. (YLB)

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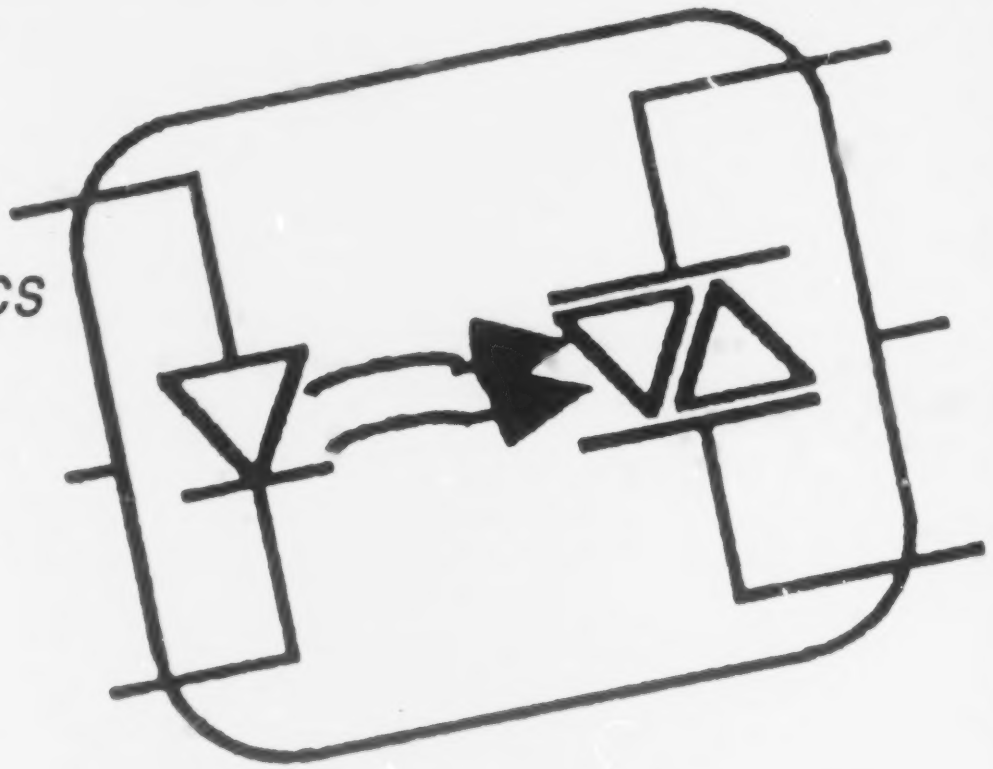
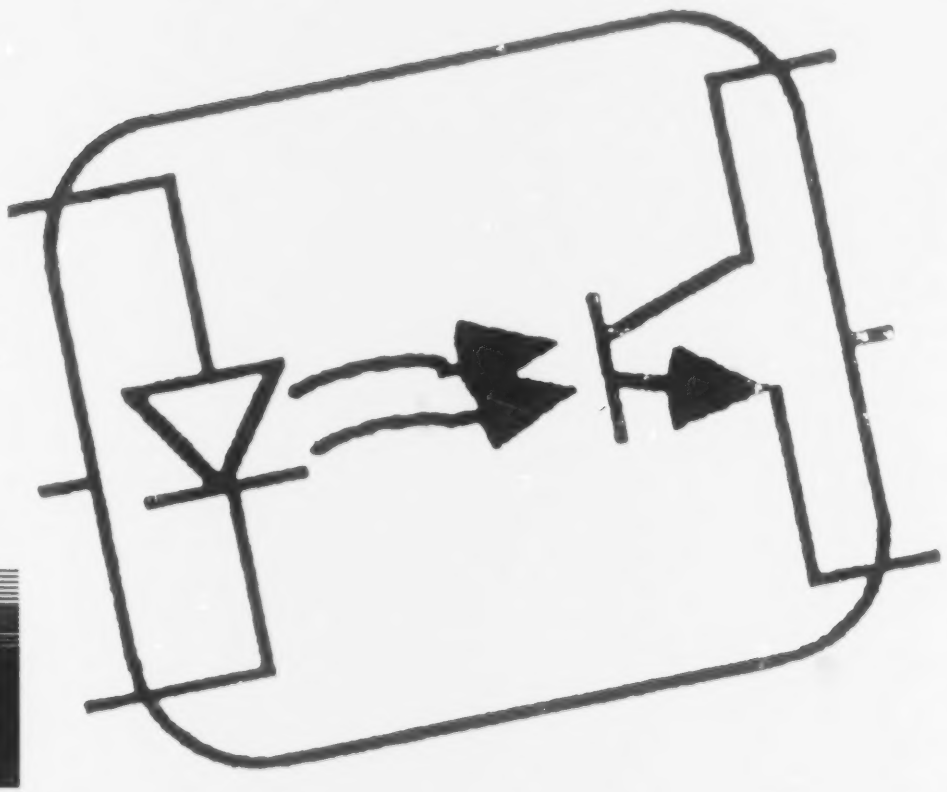
ELECTRONICS
Module

9

70-5009-1
Instructor's Guide

OPTICAL ELECTRONICS





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Modules in this IML Electronics series

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2: *Fundamentals of Electronics* by Jim Everett
3: *Digital Logic Application* by Ed Carter and Mark Murphy
4: *Circuit Construction Techniques* by Don Slack
5: *Semiconductor Devices and Applications* by John Chappell, Bill Franken and Mark Murphy
6: *Receivers and Transmitters* by Jim Everett
7: *Testing and Troubleshooting* by Don Slack
8: *Microprocessor and Computer Systems* by Don Slack
9: *Optical Electronics* by Bill Franken
10: *Electromechanical Devices and Controllers* by Ed Carter

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ELECTRONICS

Module 9: Optical Electronics

by

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1990

Instructor's Guide
Catalog No. 70-5009-I

FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. This electronics guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource--it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignment sheets and test items are keyed to specific competencies. A cross-reference table has been included to quickly identify parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future electronics curriculum modifications will begin with this guide. The electronics field is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Moore, supervisor
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Department of Elementary and Secondary Education

Charles "Chuck" Waibel, director
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Department of Elementary and Secondary Education

ACKNOWLEDGMENTS

This electronics guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the electronics competency profile developed by industry and education professionals in the state.

When searching for current electronics materials to adopt or utilize in the guide's development, comparable materials were found from the Mid-America Vocational Curriculum Consortium (MAVCC), of which Missouri is a member. MAVCC materials, therefore, have been relied upon as a resource for this guide. A debt of thanks is owed to the entire MAVCC organization for the research and development of these electronics materials.

Special appreciation is given to the writers (Ed Carter, John Chappell, Jim Everett, Bill Franken, Mark Murphy, Don Slack and Bill Tharp) for their self-motivation, reliability and technical expertise. IML employees Crystal Dietiker and Donna Curtis contributed greatly to the guide's production.

These industry representatives and educators contributed to the guide as members of the advisory committee.

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Support and contributions of IML staff members were instrumental to this module's development.

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Donna Curtis and Lori Holliday, word processors
Mary Beth Ramsey, student assistant - clerical

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Unit V: Optical encoders 79

COMPETENCIES ADDRESSED IN THIS MODULE

J. Optical Electronics

1. Describe physical aspects of light
2. Identify types of photodetectors and emitters
3. Construct a circuit using a photodetector and emitter
4. Describe optically coupled electronic systems
5. Describe optoelectronic methods of communication
6. Test and repair optical displays
7. Describe operating principals of lasers and masers
8. Describe operation principles of optical encoders

D. Semiconductor Devices

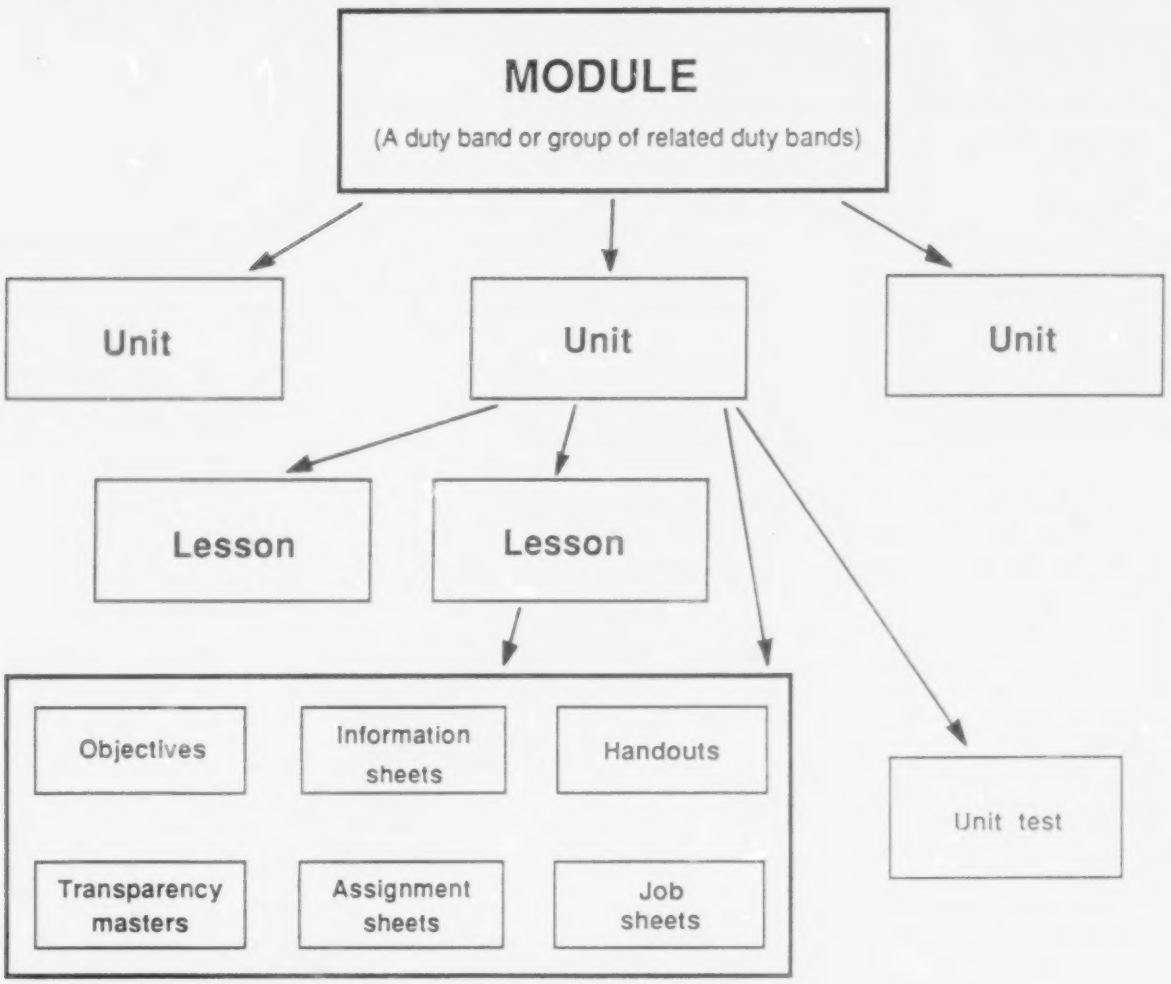
10. Describe the basic operation of a SCR
11. Describe the basic operation of a TRIAC

HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of instruction

This Electronics guide contains ten modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section near the beginning of each unit.



Competency profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

- 3 = **Mastery** - can work independently with no supervision
- 2 = **Requires supervision** - can perform job completely with limited supervision
- 1 = **Not mastered** - requires instruction and close supervision
- N = **No exposure** - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1, the second is 1.2, and so on. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section.

Information sheets (green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage, while **WARNING** statements recommend procedures to avoid bodily injury. Handouts and transparency masters have been keyed in the information sheets for instructional use.

Transparency masters (white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary and direct the class's attention to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion, however.

Handouts (white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance which might

be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), utilizing Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson-by-lesson.
4. Have students do assignment sheet(s) to satisfactory levels.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

PACKAGING

This Electronics guide has been packaged with the entire class in mind. For the teacher, a complete instructor's guide contains all ten modules. In the student reference, selected portions have been reproduced for student use (objectives page, information sheets, handouts). Student work sheets (assignment sheets, job sheets, unit tests) have been packaged together for student distribution as the instructor deems necessary.

In the student reference, page numbers do not run consecutively because some pages have been removed that appear only in the instructor's guide.

MODULE 9: OPTICAL ELECTRONICS

CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Compe-tency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
J1	I 1.1					I 11, II 3, 4	
J2	I 1.1, 1.2, II 1.1					I 3, 4, 6, 7, 15, II 2, 3, 5	
J3	I 2.5				I 2.1	I 6, 12	
J4	I 1.4, 2.1, 2.3, 2.4, II 1.2			I 1.1		I 1, 2, 5-11, 15, II 5, 6	
J5	I 1.3, 2.2, 2.4			I 2.1		I 1, 2, 5, 6, 9, 12-14	
J6	IV 1.1, 1.2, 2.1-2.2				IV 1.1	IV 1-8	
J7	III 1.1-1.3, 2.1-2.4					III 1-14	
J8	II 1.3, V 1.1-1.3, 2.1-2.3	II 1.1		II 1.1, V 1.1, 2.1	II 1.1	V 1-10	
D10-11	II 1.2					II 1	Also in Semiconductors

PARTS/EQUIPMENT LIST

5V DC source, 0.1 amp capacity
6.3V AC source, 1 amp rated
6.3V light bulb and socket
7447 seven-segment decoder driver
Capacitors: C_1 = .022μF, .1μF
DIP switches, 4
LEDs
Manufacturer's literature for the LED and seven-segment display
MF0D72 optic detector
MF0E71 optic fiber emitter (infrared)
MOC 3010 optical isolator
Multimeter with the ohmmeter function's batter[illegible]ential of more than 2V (e.g. Simpson 260)
Ohmmeter
741 op amps (2)
Oscilloscope (capable of being triggered)
Potentiometer, 1K
Potentiometer, 10KΩ
Power supply, 9V at 100mA
Resistors: 270Ω, 1/2 watt; 7 resistors of a value determined by the seven-segment display
Resistors: R_1 = 47K, R_2 = 100, R_3 = 1M, R_4 = 5.6K, R_5 = 2.2K, R_6 = 330
Resistors: R_1 = 330 + 1K pot., R_2 = 1K, R_3 = 330
Resistors: 0.5 watt, 100Ω, 180Ω
Seven-segment display
SK-10 or similar construction board
555 timer
TRIAC, ST136 or equivalent
Variable power supply, at least $2V_{DC}$

MODULE: OPTICAL ELECTRONICS

UNIT I: FIBER OPTIC CABLE

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe the basic terms used in fiber optic cable construction and system applications. He/she should be able to describe some of the advantages of and considerations for fiber optic selection and applications. This knowledge will be evidenced by achieving a specified score on the job sheet and unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Define terms and definitions.

1.2 Describe the components and operation of a fiber optic transmission system. (competency J2)

1.3 Describe the advantages of fiber optics over conventional electrical current transmission media. (competency J5)

1.4 Describe the types of materials used in a fiber optic cable.

2.1 Identify fiber optic link components. (competency J4)

2.2 Identify various communication formats. (competency J5)

2.3 Describe basic laser characteristics. (competency J4)

2.4 Describe types of communication systems. (competencies J4 and J5)

2.5 Construct a circuit using a photodetector and emitter. (competency J3, JS 2.1)

MODULE: OPTICAL ELECTRONICS

UNIT I: FIBER OPTIC CABLE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: INTRODUCTION

   a. Information outline

   b. Assignment sheet

      AS 1.1: Basic concepts of fiber optics

   c. Answers to assignment sheet

2. Lesson 2: COMMUNICATIONS

   a. Information outline

   b. Assignment sheet

      AS 2.1: Concepts of fiber optics

   c. Answers to assignment sheet

   d. Job sheet

      JS 2.1: Construct a circuit using a photodetector and emitter

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Miller, Gary M. Modern Electronic Communication. 3rd ed. Englewood Cliffs, NJ: Prentice Hall, 1988.

2. Kennedy, George. Electronic Communication Systems. 3rd ed. New York: McGraw Hill, 1985.

3. Bates, Paul. Practical Digital and Data Communications. Englewood Cliffs, NJ: Prentice-Hall, 1987.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Demonstrate or describe real-world applications and local installations.

2. Use articles in trade magazines, newspapers and other publications to introduce recent trends.

3. Obtain kits of cable, transmitters and receivers from local sources. These kits and their informational packets will add to the unit.

4. Obtain films or videos from the local telecommunications firms that explain the importance of fiber optics to the industry.

5. Show samples of fiber optic cable, which are available from local electronics stores. Also, end pieces can be obtained from local telecommunications firms.

B. Suggested student activities

1. Schedule field trips to view local installations.

2. Assign a library research project to report on new trends, the economics or the implications of fiber optics for technicians (or other topics of the student's choosing).

3. Have students sketch the block diagram of an elementary fiber optic system and the components that make up the fiber optic cable.

MODULE: OPTICAL ELECTRONICS

UNIT I: FIBER OPTIC CABLE

LESSON 1: INTRODUCTION

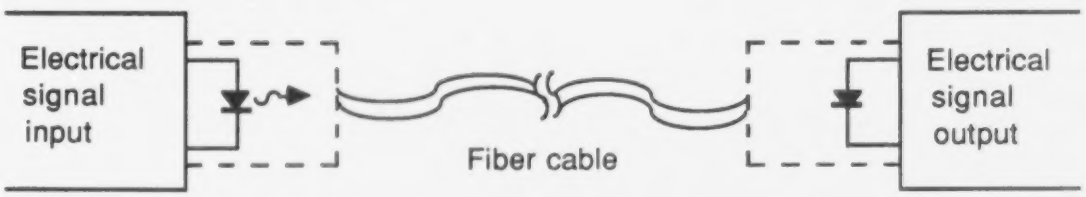
I. Terms and definitions

A. Attenuation--the decrease in the strength of the light (or other signal) as the distance of travel through the cable increases

B. Bandwidth--range of frequencies that any conductor can pass. In fiber optics, the higher the frequency, the greater the amount of information that can be transmitted at any given time.

C. Cladding--coating around the fiber optic cable itself

D. Fiber optics--method of cabled communication and data transmission using modulated light through an optical cable



Typical one-direction fiber optic system

E. Link--assembly of hardware which connects a signal's source with its ultimate destination. The system consists of the transmitter, receiver and the fiber cable connecting them.

F. Modulation--system which varies the amplitude or intensity of the light beam. This modulation can be either pulsed on and off or by an analog signal.

II. Components and their operation

A. Everything from the input signal connector to the output signal connector can be pre-packaged or fully transparent to the user.

1. With this, the user need only be concerned with supplying a standard-level signal and extracting a similar signal.

2. Such a system eliminates the need for a designer or technician to understand fiber optics. However, by understanding a link's problems and concepts, the user can better apply fiber optic technology to the system.

B. A **transmitter's** input signal is used to modulate a light source.

1. Laser

a. Modulated light source

b. Has been used successfully without repeaters over distances of several hundred miles or more

2. Fast-acting LED (light-emitting diode) like gallium arsenide for short-distance applications (component to component)

3. Modulated light coupled into the optical fiber

   a. This is a critical element of the system.

   b. Based upon the coupling scheme used, the light coupled into the fiber could be two orders of magnitude less than the total power of the source.

C. The **receiver** varies conduction in response to the light modulation.

1. There are three types.

   a. Photo detector

   b. Photo diode

   c. Photo transistor

2. The light coupling problem at the receiving end, although of concern, is considerably less severe than at the source end.

3. Upon receipt, the detector signal is decoded to reconstruct the original input signal.

D. **Fiber cable** is the core material that is the conducting medium.

1. Cladding is the fiber cable's external shield.

2. Light is reduced as it travels along the fiber.

3. Light is also subject to distortion as it travels along the cable. The degree of distortion limits the maximum data rate that can be transmitted through the fiber.

E. Bi-directional communications can take place on a single cable when each end of the fiber has a transmitter and receiver within the termination.

III. Advantages of fiber optics

A. Greater bandwidth

1. The higher the carrier frequency in a communication system, the greater its potential signal bandwidth.

2. Since fiber optics work with carrier frequencies of 10^{13}-10^{14} Hz (as compared to radio frequencies of 10^{6} to 10^{8} Hz), signal bandwidths are theoretically 10 times greater.

B. Smaller size and weight

1. A single fiber is capable of replacing a very large bundle of individual copper wire.

   Example: A typical telephone cable may contain over 1000 pairs of copper wire and have a cross-sectional diameter of 7-10 cm. A single glass fiber cable, capable of handling the same amount of signals, may be only 0.5 cm in diameter.

2. The actual fiber can be as small as 500μm. The additional size is the jacket and strength elements.

3. Weights are significantly less.

C. Lower attenuation

1. Length for length, optical fiber exhibits less attenuation than does twisted wire or coaxial cable.

2. The attenuation of optical fibers, unlike that of wire, is not signal-frequency dependent.

3. Factors contributing to attenuation

   a. Imperfections at the core/clad interface

   b. Flaws in the consistency of the core material

   c. Impurities in the glass composition

4. All wavelengths affected by surface imperfections and material flaws

   Example: Hydroxyl molecules (OH) are strong absorbers of light at 900 nm (nanometers). Therefore, if a fiber manufacturer wants to minimize losses at 900 nm, it will have to take exceptional care to eliminate moisture (a source of OH).

D. Freedom from interference

1. Unlike wire, glass does not pick up or generate electromagnetic interference (EMI).

2. Optical fibers do not require expensive shielding to desensitize them from stray electromagnetic fields.

E. Ruggedness

1. Glass is 20 times stronger than steel.

2. Since glass is relatively inert, corrosive environments are less of a concern than with wired systems.

F. Safety

1. Special precautionary designs are required in many wired systems to prevent short circuits between wires or from wires to ground. This is not true with fiber optics.

2. Since there is no current flow, there is no concern for hazardous electrical sparks during interconnects.

G. Lower cost

1. Optical fiber costs are continuing to decrease, while the cost of wire is increasing.

2. In many applications, the total system cost for a fiber optic design is lower than for a comparable wired system.

IV. Fiber types

A. Plastic core and cladding

1. Extremely rugged and useful, the cable can be subjected to rough treatment day after day.

2. Plastic is used for bench-top interconnections or component-to-component connections within a unit.

3. One disadvantage is plastic's high-attenuation (reduction) characteristic.

B. PCS (plastic clad silica)

1. Has a core of glass for low attenuation

2. Less affected by radiation than all-glass fibers

3. Used in many military applications

C. Glass core and cladding (silica-clad-silica)

1. Extremely pure glass material used for long distances due to its low attenuation factor

2. Allows higher information transmission rates than plastic since it permits shorter wavelengths of light to travel through

3. Good concentricity, even for small-diameter cores

4. Easier to terminate than PCS

5. Least mechanically rugged

6. More susceptible to increases in attenuation when exposed to radiation

BASIC CONCEPTS OF FIBER OPTICS

1. Sketch the basic components of a one-direction fiber-optic communication system.

2. How could this system be modified so that two-way communications could take place on the single cable?

3. List at least five advantages of fiber optics over conventional transmission systems.

   a.

   b.

   c.

   d.

   e.

4. What two materials are commonly used for fiber optic cable?

5. Which material would be used for long-distance communication links? Why?

6. Fiber optic cable can handle a greater _____ bandwidth than conventional cable. (Fill in the type of bandwidth.)

7. What is a typical dimension of long-distance fiber cable?

8. Why is freedom from electromagnetic interferences (EMI/RFI) an important advantage of fiber optic cable?

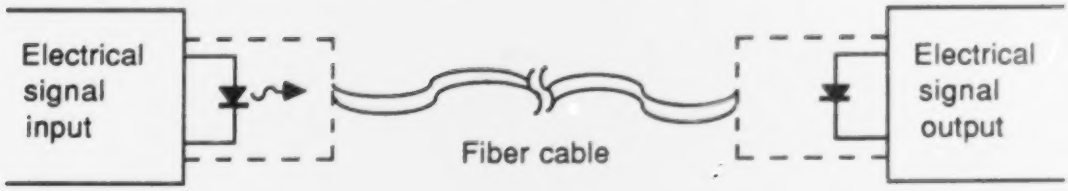
9. How does the strength of glass compare to that of steel or other metals?

10. Why is fiber optic cable safer than conventional wiring from an electrical standpoint?

11. Why is it important that the conducting medium (glass or plastic) be kept extremely pure as it is manufactured?

ANSWERS TO AS 1.1

1.



2. A Y input/output at each end will allow a transmitter and receiver at each end.

3. Any five of the following:
Greater bandwidth
Smaller size and weight
Lower attenuation
Freedom from interference
Ruggedness
Safety
Lower cost

4. Glass and plastic

5. Glass--less loss or attenuation

6. Frequency

7. The cable, including cladding, can be as big as .5cm. The fiber can be as small as 500μm.

8. Many locations have difficulty shielding their huge electromagnetic fields from conventional cables.

9. Glass is as strong or stronger than other materials, but it is also more brittle.

10. No sparks are created at the connections, and no heat is generated in the cable.

11. Impurities absorb light, increasing loss.

MODULE: OPTICAL ELECTRONICS

UNIT I: FIBER OPTIC CABLE

LESSON 2: COMMUNICATIONS

I. The fiber optic link consists of three elementary components.

A. Signal processor or modulator, which converts the intelligence or what is to be transmitted into light variations

B. Fiber optic cable

1. This cable consists of the two end connectors and the fiber cable.

2. The two end connectors are the only components that require special splicing to assure that the cut of the cable is clean and square for maximum transmission of light.

C. Signal processor or demodulator, which converts the light variations into intelligence

II. Communication formats

A. Analog

1. Signal consists of variations in the light intensity

2. Difficult to time share or multiplex

B. Digital

1. Digital transmission is more common than analog.

2. Using an analog-to-digital conversion process at the input and a digital-to-analog conversion at the output, any analog signal can be converted to digital for the fiber link.

3. Digital's advantage is that it can be packaged or compressed into brief bursts of information during the transmission through the fiber link and then expanded on the other end, allowing many messages to share the cable at what seems to be the same time.

C. Protocol--agreement between the sender and the receiver regarding what the digital signal must look like (needed for communication to take place)

1. Return-to-zero or non-return-to-zero convention

2. Word length in bits

3. Parity

4. Transmission rate

5. Word-code system used

III. Laser

A. Laser is the acronym for light amplification by stimulated emission of radiation.

B. Lasers emit radiation at one wavelength or frequency.

C. The light output is coherent, which means that the frequency and phase of the light produced is locked together.

1. Produce a beam of light that separates very little over distance

2. Used for long-distance transmissions

D. To be practical in communications, the laser must be able to be modulated by the intelligence being transmitted.

E. Gallium arsenide (GaAs) is the material commonly used in current laser technology.

IV. Communication systems

A. Half duplex

1. Single-direction system

2. Example: communication from a computer to a printer

B. Full duplex

1. Two-way or bi-directional communication system

Example: Telephone link

2. Has a termination that splits the fiber optic cable into a Y

a. One leg is connected to the transmitter.

b. The other leg is connected to the receiver.

c. A single termination of the fiber optic cable can be used as the source and as a transmitter.

C. Multiplexing signals

1. Multiplexing in its simplest form is time sharing.

a. A given transmitter and receiver use only a small time slot for their communications.

b. The rest of the time is given to other pairs of communicators.

2. Multiplexing of the signals is used to achieve an increased volume of messages on a single cable.

3. Additional techniques are possible, including variations in the color of the light beam, phase multiplexing and others.

D. Demultiplexing is the synchronized system that allows the receiver to listen only during the time that the signal of interest is present.

CONCEPTS OF FIBER OPTICS

1. What are multiplexing techniques? Why are they important to fiber optic cable?

2. What is full-duplex communications?

3. What is laser an acronym for?

4. What is meant by the term protocol?

5. What is commonly done to analog signals before injection into a fiber cable?

ANSWERS TO AS 2.1

1. Data is compressed and sent as a microburst. The time gained can be used by other signal sources. This multiple use of a cable is called multiplexing.
2. Two-way communications
3. Light amplification by stimulated emission of radiation
4. The agreed-upon arrangement for digital communications
5. Convert them to digital

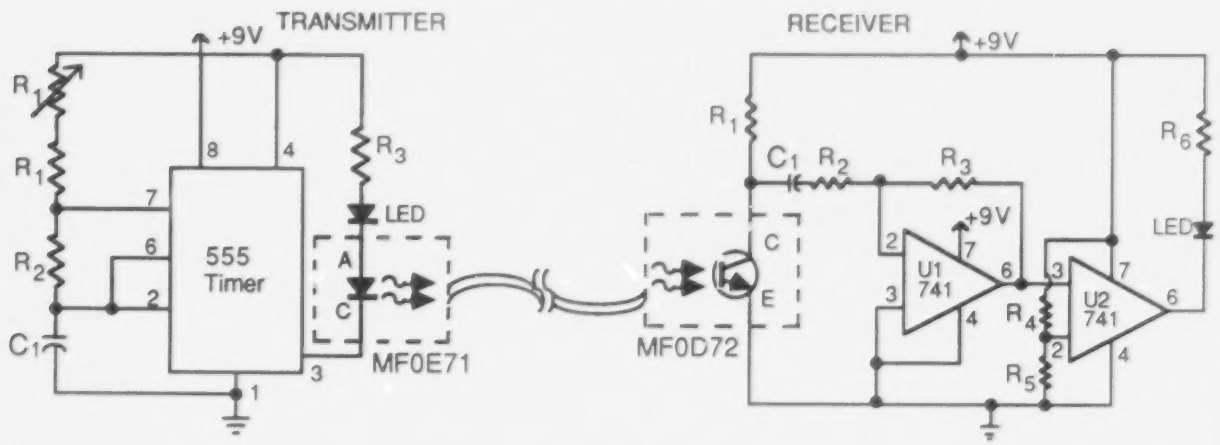
CONSTRUCT A CIRCUIT USING A PHOTODETECTOR AND EMITTER

Equipment:

Oscilloscope (capable of being triggered)
1K potentiometer
SK-10 or similar construction board
9V power supply at 100mA

Transmitter
555 timer
LED
MF0E71 optic fiber emitter (infrared)
Resistors: R_1 = 330 + 1K pot.
R_2 = 1K
R_3 = 330
Capacitor: C_1 = .022μF

Receiver
LED
MF0D72 optic detector
741 op amps (2)
Resistors: R_1 = 47K
R_2 = 100
R_3 = 1M
R_4 = 5.6K
R_5 = 2.2K
R_6 = 330
Capacitor: .1μF



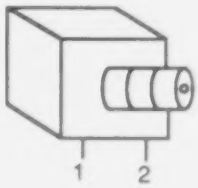
INSTRUCTOR'S NOTE: An ECG3028 can be substituted for the MF0E71 emitter, and an ECG3031 can be substituted for the MF0D72 detector. The capacitor will then need to be .47μ or larger and R_5 reduced to 1.6KΩ.

Procedure:

Evaluation 3 2 1 N

1. Build the transmitter and receiver shown above. The pin-outs of the fiber optic emitter and detector are: — — — —

   MF0E71--1 = anode, 2 = cathode
   MF0D72--1 = emitter, 2 = collector



   NOTE: The test circuit for this job sheet uses a 555 timer to pulse an infrared LED in the emitter at a frequency determined by R_1, R_2 and C_1. The other LED is dimly lit when a signal is being transmitted and flashes at the same rate as the fiber optic cable via photo transmitter conduction. When the pulse is low, MF0E71 is lit. This light is sent through the cable to the base of MF0D72, causing the photo transistor to conduct, which sends the signal to the op amp for conditioning and amplification. The output at pin 6 of U_2 should be very similar to pin 3's output on the 555 timer.

2. Measure and record oscilloscope waveforms for each circuit location below. — — — —

   a. Frequency and amplitude of pin 3, 555 timer signal

   _____

   b. Frequency and amplitude of collector, MF0D72

   _____

   c. Frequency and amplitude of pin 6, U_2

   _____

3. How much attenuation was observed through the fiber? — — — —

   Was the receiver output similar to the transmitted signal?

4. Disconnect the fiber from the infrared LED and aim it toward the other LED in the transmitter circuit. (Hold it steady and directly on the LED surface.) Observe the receiver frequency output (pin 6). (The system should still work about the same.) — — — —

5. Now aim the fiber at fluorescent lights. What frequency is observed? _____ (120 Hz?) Try it with other light sources. — — — —

6. Vary the frequency of the transmitter by adjusting R_1. Record the receiver output (pin 6) indication. _____ — — — —

   Did the output accurately reflect transmitted data? _____

7. Using a schematic diagram and written description, describe a scheme to couple a computer output with a second computer input using the fiber optic link. — — — —

8. Return equipment to its proper storage location. — — — —

Average of above evaluation* — — — —

*This average is the student's final evaluation for competency J3: Construct a circuit using a photodetector and emitter.

MODULE: OPTICAL ELECTRONICS

UNIT I: FIBER OPTIC CABLE

UNIT TEST

Select the option which answers the question or completes the statement.

___ 1. What is the term used to describe one-way communications?

a. Half duplex
b. Full duplex
c. Multiplexing
d. Demultiplexing
e. Single line

___ 2. What is the term used to describe time sharing of a communications link?

a. Half duplex
b. Full duplex
c. Multiplexing
d. Demultiplexing
e. TASI

___ 3. Which term describes the loss of signal strength in a fiber optic link?

a. Reflection
b. Rise time
c. Compression
d. Impurities
e. Attenuation

___ 4. Which is <u>not</u> a part of the optical fiber cable?

a. LED
b. Cladding
c. Sheath
d. Core
e. Fiber

___ 5. Is an analog or digital link preferred? Why?

a. Analog because the fidelity of the information is better
b. Analog because more information can be transmitted on one cable
c. Digital because the fidelity of the information is better
d. Digital because more information can be transmitted on one cable
e. Neither--they are equally favored.

___ 6. Why is the laser used in a fiber optic link?

a. It has coherent light.
b. It is more powerful than the LED.
c. The frequency of the laser light travels better through fiber cable.
d. It is cheaper than the LED.
e. It is smaller than the LED.

____ 7. Which of the following statements is the most true regarding the fiber cable connections?

a. The ends must be cut at a precise 45° angle.
b. A small-diameter fiber cable will carry the light signal as far as a large-diameter fiber cable.
c. The ends must be cut at a precise 90° angle.
d. A large-diameter fiber cable has more light loss due to internal reflections than does a small-diameter fiber cable.
e. The cladding is made of a spongy material.

____ 8. In fiber optics, how is the system (transmitter, cable and receiver) referred to?

a. Link
b. Fiber cable
c. Network
d. Cladding
e. Up/down link

____ 9. What are the elementary methods of transmitting information through a fiber optic system?

a. Analog and time variations
b. Analog and multiplexing
c. Digital and analog
d. Digital and multiplexing
e. Pulsed analog

____ 10. What is the process of turning the light of the transmitter on and off called?

a. Pulsing
b. Modulation
c. Amplitude variation
d. Information coupling
e. Flickering

____ 11. What is the frequency range for light through fiber cable?

a. 10^2-10^4 Hz
b. 10^6-10^8 Hz
c. 10^8-10^{10} Hz
d. 10^{10}-10^{12} Hz
e. 10^{13}-10^{14} Hz

____ 12. Which will <u>not</u> affect the attenuation of a fiber cable?

a. Impurities
b. Surface flaws
c. Cladding thickness
d. Imperfections at the fiber core/cladding bond
e. Cable material

____ 13. Which fiber optic material is best suited for a short distance transmission, such as bench-top to bench-top?

a. Glass core with plastic cladding
b. Plastic core with plastic cladding
c. Glass core with glass cladding
d. Plastic core with metallic cladding
e. Plastic core with braided cladding

____ 14. Which fiber optic material is suitable for a long distance, such as city to city?

a. Glass core with plastic cladding
b. Plastic core with plastic cladding
c. Glass core with glass cladding
d. Plastic core with metallic cladding
e. Glass core with rigid steel cladding

____ 15. Which fiber optic material has the best resistance to radiation?

a. Glass core with plastic cladding
b. Plastic core with plastic cladding
c. Glass core with glass cladding
d. Plastic core with metallic cladding
e. Glass core with lightening arrestors

ANSWERS TO UNIT TEST

1.	a	(J4, J5)
2.	c	(J4, J5)
3.	e	(J2)
4.	a	(J2)
5.	d	(J4, J5)
6.	b	(J2-5)
7.	c	(J2, J4)
8.	a	(J4)
9.	c	(J4, J5)
10.	b	(J4)
11.	e	(J1, J4)
12.	c	(J3, J5)
13.	b	(J5)
14.	a	(J5)
15.	a	(J2, J4)

MODULE: OPTICAL ELECTRONICS

UNIT II: OPTICAL COUPLER

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to explain the basic operation and applications of the optical isolator. This knowledge will be evidenced by achieving the specified score on the job sheet and unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Describe the construction of the diode optocoupler. (competency J2)

1.2 Describe basic applications of the optical isolator. (competency J4)

1.3 Describe operation principles of optical encoders. (competency J8, JS 1:1)

MODULE: OPTICAL ELECTRONICS

UNIT II: OPTICAL COUPLER

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the Instructor

D. Lesson plan

1. Lesson 1: OPTICAL COUPLERS

   a. Information outline

   b. Transparency master

      TM 1.1: Optocouplers

   c. Assignment sheet

      AS 1.1: Optical couplers

   d. Answers to assignment sheet

   e. Job sheet

      JS 1.1: Describe operation principles of optical encoders

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Pearman, Richard H. Solid State Industrial Electronics. Reston, VA: Reston Publishing Company, 1984.

2. Maloney, Timothy J. Industrial Solid State Electronics. Englewood Cliffs, NJ: Prentice Hall, 1986.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Demonstrate how to identify pins on the optical isolator integrated circuit.

2. Demonstrate testing of the optical isolator for function.

3. Demonstrate applications of the optical isolator.

B. Suggested student activities

1. Take students on field trips to industrial settings or factories that have programmable logic controllers, for example.

MODULE: OPTICAL ELECTRONICS

UNIT II: OPTICAL COUPLER

LESSON 1: OPTICAL COUPLERS

I. Optocouplers or optoisolators

A. Purely electronic components, usually in a six-pin, DIP-format integrated circuit

B. Primary use is similar to that of the isolation transformer, although the operation is quite different

C. Construction

1. Infrared light-emitting diode separated from a photosensitive transistor by a transparent medium

2. Transistor at the output

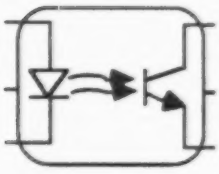
a. PN junction transistor for DC outputs

b. Commonly a TRIAC for AC outputs

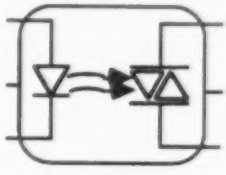
3. Encased in an opaque package to prevent external light from interfering with the operation

4. No electrical connection between the LED input and the phototransistor. As a result, there is total electrical isolation between the input and the output.

D. Symbols for the optocoupler



Optocoupler
(transistor output)



Optocoupler
(TRIAC output)

II. Optical couplers

A. Applications of the optical coupler

1. Computer-to-instrumentation interface in industrial equipment

a. In a factory setting, large motors and transformers are a constant source of electrical interference.

b. If there is a distance between the instrument and the computer, electrical lines can act as the secondary of a transformer and pick up large, potentially damaging voltage spikes.

c. The optical isolator can prevent voltage spikes as large as 10-20,000 volts from crossing.

2. Computer-to-motor controls interface in the programmable logic controller output in industrial equipment.

   a. Motor starters normally use 110V AC, while the computer uses TTL.

   b. The optical isolator is used to convert the voltage levels from one to the other.

3. Phone modems--between the phone line and the computer

   a. The phone line is a potential source of high-voltage spikes from a variety of inputs (bell ringers to lightning).

   b. The optical isolator serves the same purpose as it does in industrial settings.

B. Operation of the optical coupler

1. LED power requirements are low--typically equal to one or two TTL loads.

2. To identify pins, the manufacturer's reference guide must be used. Different optical isolators have different pin configurations, depending on the manufacturer's interests.

3. For DC control systems, the optical-switched transistor is the device of choice. It is essentially a transistor that uses the varying light levels in much the same way that the junction transistor uses base current.

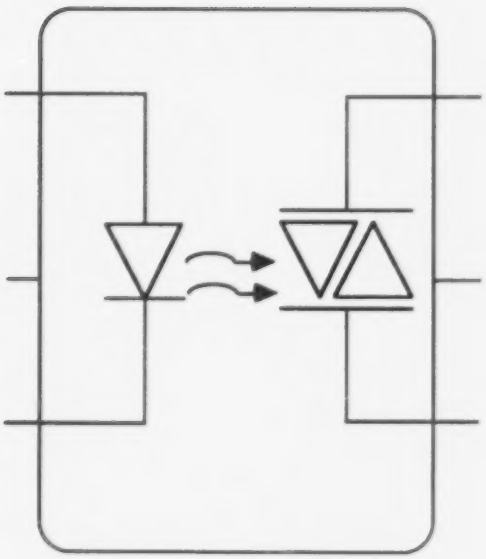
4. For AC control, the optical-switched SCR or TRIAC is the device of choice.

   a. The SCR or TRIAC is turned on by the presence of light.

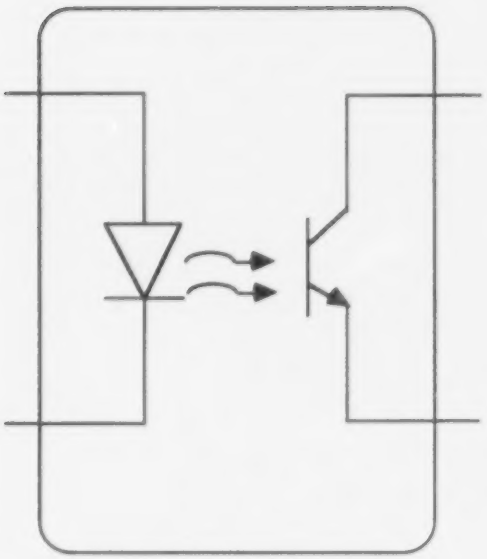
   b. Remember that both of these devices will not turn off until the current through the main terminals drops below the threshold value.

   c. The SCR or TRIAC optical isolator usually incorporates an internal network called the zero crossover detector. This network keeps the SCR or TRIAC from firing until the line voltage is crossing through a zero voltage value.

OPTOCOUPLERS



TRIAC output



Transistor output

OPTICAL COUPLERS

1. Why are the SCR or TRIAC optical couplers used for AC applications?

2. What is the connecting medium between the input and the output of the optical isolator?

3. What is the principal reason why the optical isolator might be used in a long-distance instrumentation setting (such as 1/4 mile between the input to the computer)?

4. Why is the optical isolator used in the telephone modem?

5. How does the technician determine the function of the pins of an optical isolator?

6. Make a sketch of the pins and the internal components of the MOC 3010 optical isolator.

   NOTE: Refer to an RCA, General Electric or similar reference manual.

ANSWERS TO AS 1.1

1. They isolate the load from the control equipment. The SCR or TRIAC is used because they turn off at the zero voltage or current point of the line voltage.

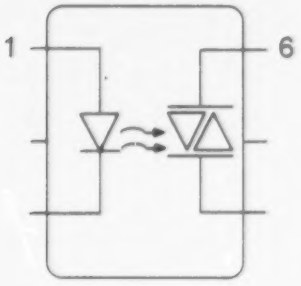
2. Light

3. To prevent electromagnetic-induced pulses from being introduced back into the controller (usually a computer)

4. To keep noise out of the computer

5. By referring to manufacturer product reference manuals

6.



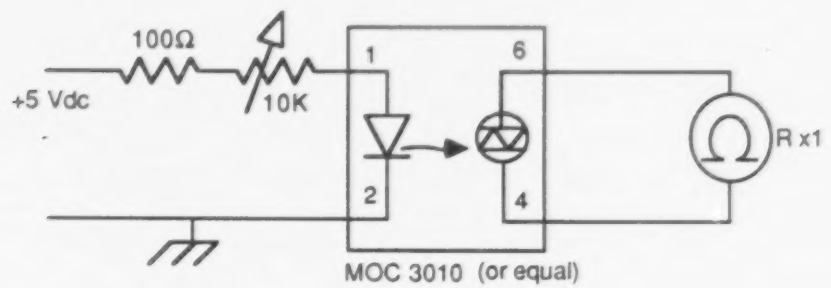
DESCRIBE OPERATION PRINCIPLES OF OPTICAL ENCODERS

Equipment:

Ohmmeter
MOC 3010 optical isolator
Resistors: 0.5 watt, 100Ω, 180Ω
10KΩ potentiometer
TRIAC, ST136 or equivalent
6.3V light bulb and socket
6.3V AC source, 1 amp rated
5V DC source, 0.1 amp capacity

Procedure:

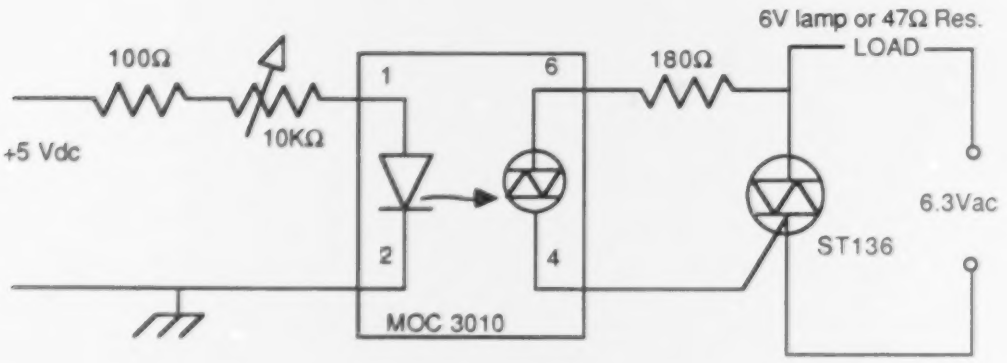
		Evaluation 3	2	1	N
1.	Connect the circuit below. Make sure that the variable resistor is at maximum.	—	—	—	—



2.	Measure the resistance indicated between the TRIAC output terminals. (It should be infinity.) Resistance = _____	—	—	—	—
3.	Slowly decrease the resistor until the ohmmeter indication drops toward a low value. Resistance = _____	—	—	—	—
4.	Remove the five-volt supply and note the ohmmeter indication.	—	—	—	—
5.	Disconnect and reconnect the ohmmeter; note the indication. What does this say about the characteristic of the output section of the OC?	—	—	—	—

NOTE: The indication should have remained low until the ohmmeter was disconnected and reconnected.

6. Connect the circuit below. — — — —



NOTE: The resistor must be set to maximum.

7. Gradually reduce the resistance of R_1 until the TRIAC fires. — — — —

NOTE: Firing of the TRIAC will cause the external TRIAC to fire. If a lamp is used, the lamp will glow. If an oscilloscope is used to indicate firing, the AC indication across the external TRIAC will drop to a very low value and all of the line will appear across the load.

8. Draw and explain the waveforms that appear across the external TRIAC and the load. — — — —

TRIAC LOAD

9. Return equipment to its proper storage location. — — — —

Average of above evaluation* — — — —

*This average is the student's final evaluation for competency J8: Describe operation principles of optical encoders.

MODULE: OPTICAL ELECTRONICS

UNIT II: OPTICAL COUPLER

UNIT TEST

Select the option which answers the question or completes the statement.

___ 1. Which type of output is commonly used to drive a DC system?

a. SCR
b. TRIAC
c. Junction transistor
d. LED
e. Operational amplifier

___ 2. To which of the optical isolator components is the input applied?

a. SCR
b. TRIAC
c. Junction transistor
d. Clear medium
e. LED

___ 3. What is a typical voltage-isolation capacity of the optical isolator?

a. 5V maximum
b. 500V maximum
c. 5000V maximum
d. 20,000V maximum
e. 25,000V maximum

___ 4. Which of the following terms means that no light can pass through it?

a. Translucent
b. Transparent
c. Opaque
d. Clouded
e. Occluded

___ 5. What is the optical isolator similar in function to?

a. Amplifier
b. Transformer
c. Headlight
d. Antenna
e. Transistor

___ 6. Which component within the optical isolator is used to synchronize the turn-on with the line-voltage phase?

a. Zero crossover detector
b. Frequency synchronizer
c. LED
d. TRIAC
e. Transformer

ANSWERS TO UNIT TEST

1. c (D10, D11)
2. e (J2)
3. d (J1, J2)
4. c (J1)
5. b (J2, J4)
6. a (J4)

MODULE: OPTICAL ELECTRONICS

UNIT III: LASERS AND MASERS

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to describe development of the laser, basic operation, terms, general applications and uses. This knowledge will be evidenced by achieving the specified score on the unit test.

SPECIFIC OBJECTIVES

1.1 Define terms associated with the laser.

1.2 Describe major milestones of maser and laser development.

1.3 List applications of the laser.

2.1 Describe principles of laser operation.

2.2 Identify substances used to power lasers.

2.3 Describe ruby laser construction components.

2.4 Discuss gas laser construction, operation and focusing. (competency J7)

MODULE: OPTICAL ELECTRONICS

UNIT III: LASERS AND MASERS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: INTRODUCTION

   a. Information outline

2. Lesson 2: OPERATION AND CONSTRUCTION

   a. Information outline

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Safford, Edward L. Fiber-optics and Laser Handbook. Blue Summit, PA: TAB Books, Inc., 1984.

2. Maurer, Allan. Lasers, Light Wave of the Future. New York: Arco Publishers, 1982.

3. Bertolotti, Mario. Masers and Lasers: An Historical Approach. Bristol, British Isles: A. Hilger, 1983.

B. Periodicals

1. Farnum, Gregory T. "Measuring With Lasers." Society of Manufacturing Engineering Magazine Feb. 1986: 47. (Published by the Society of Manufacturing Engineers, P.O. Box 930, Deerborn, MI 48121.)

2. Farnum, Gregory T. "Laser Welding Improves Can Production." Society of Manufacturing Engineering Magazine Oct. 1986: 67.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. The laser is one of the most important developments of the 20th century. Laser applications range from replacing the transit in the leveling of parking lots or suspended ceilings to high-speed switching systems in a modern telecommunications system.

2. It is not important that the student have an in-depth understanding of the construction or theory of the laser as there is little to maintain. It is, however, important to understand the underlying principle and systematic applications of the laser.

3. During instruction, use as many examples of the laser as possible.

4. Safety during the use of the laser must be strongly emphasized.

MODULE: OPTICAL ELECTRONICS

UNIT III: LASERS AND MASERS

LESSON 1: INTRODUCTION

I. Terms and definitions

A. Monochromatic light--that which is composed of a single color or a single frequency

B. Coherent light--where all waves are in harmony with each other. The term "coherent" means "sticks together". Light that is coherent behaves much like the air waves in a resonant tube, such as a flute.

C. Laser--acronym for Light Amplification by Stimulated Emission of Radiation

D. Population inversion--when there are more electrons in the excited state than in the ground state; triggers an energy release and photon emission when they return to a lower energy level

E. Pulse modulation--the controlled turning on and off of a laser; measured in the percentage of time on pulse to the start of the next

II. Historical background of the laser

A. In 1916 Albert Einstein first introduced the concept of stimulated emission, which is basic to the laser effect.

1. It was a concept which, at the time, had little application.

2. It did, however, lead to the invention of the florescent lamp, a light source that operates on the principle of electrons being stimulated into high-energy levels and subsequently releasing photons of energy as they return to the normal low-energy level.

B. The next step was called the maser (short for Microwave Amplification by Stimulated Emission of Radiation).

1. The invention of radar and a later need to produce even higher radar frequencies led to the maser's development.

2. The first maser did not operate within the visible spectrum.

3. It was the first device that operated on the principle of resonance of electrons as they change state.

C. Dr. Theodore Maiman, an engineer in California, is credited with the invention of the first true working laser in 1960.

1. Dr. Isaac Asimov, the noted author, recognized the maser's uniqueness: "It is not often that man creates something totally new. As far as we know, it was a variety of light never before seen by the eyes of man . . . a variety of light that never existed on earth before, or in any part of the universe that we can see."

2. However, Dr. Maiman's creation was a terribly inefficient device. This first laser beam lasted only one millisecond.

3. While the work content of this first laser was insignificant, it did open a door into a totally new world of electronics.

4. The actual patent for the laser was awarded in 1977 to scientist Gordon Gould after a 20-year legal battle with the U.S. Government.

III. Laser applications

A. The manufacturing industry commonly uses lasers to cut and weld metals.

B. In communications, the laser is used as the carrier for information in the same way that radio frequencies are used.

C. Lasers are used to measure distance traveled in precision machine operations, as well as to accurately measure the distance between the earth and the moon.

D. Medical uses include eye surgery, wound cauterization and countless other applications.

E. In retailing, the check-out stand's laser scanner is an example of the laser integrated into a larger system.

1. A laser scanner can read the Universal Product Code (UPC) to within 180° with its holographic, wrap-around beam.

2. When the product is put on the store's shelf, the store's computer is programmed with the retail price.

3. As the product is scanned, the computer looks up the price and rings it in the register.

4. Hidden from the transaction is inventory control. As the program dictates, the computer can maintain inventory status and prepare replacement reports.

F. For crime prevention, a laser reader is used on "old" finger prints from crime scenes.

G. Laser disks for entertainment and computer programs have progressed rapidly from read-only disks to read-write disks.

H. Future applications fill an ever-growing list.

1. In the garment industry, a laser-wielding robot will cut material in response to programmed instructions.

a. As part of an integrated system, this process may make custom-made garments even more affordable than the current mass-produced clothing.

b. This system should reduce material waste, improve the quality of the cut and reduce labor costs.

2. Atomic fusion is another laser application.

a. The laser's intense heat and focusing abilities make it an ideal candidate for the heat source to produce atomic fusion.

b. Fusion, which melds atoms together, releases nuclear energy.

c. The result will be the release of tremendous amounts of atomic energy without the possibility of a runaway reaction that is possible with the atomic fission process.

MODULE: OPTICAL ELECTRONICS

UNIT III: LASERS AND MASERS

LESSON 2: OPERATION AND CONSTRUCTION

I. Principle of operation

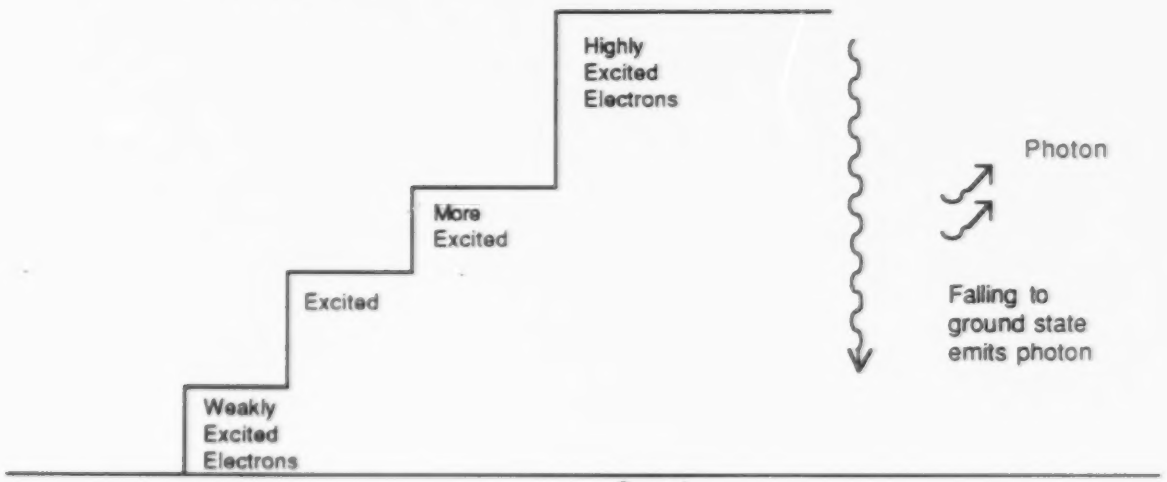
A. Laser electron orbital arrangement

1. Laser operation is based on the use of stimulated emission of electromagnetic radiation in a medium of molecules or atoms with more particles in the higher, excited state than in the lower state (an inverted population).

2. Atoms gain energy by the absorption of that energy from some external source.

3. As the atom absorbs energy, electrons are driven to a higher energy level.

4. When the electrons return to a lower level, the gained energy is released in the form of a photon of energy.



Steps of light emission

5. All lasers work in the same basic way. Atoms or molecules are excited to amplify the light intensity by stimulating the emission of coherent photons of light.

B. Normal electron arrangement

1. All material has electrons that are constantly changing from one energy level to another.

2. This is normally random and does not necessarily involve the release of light.

II. Laser "fuels"

A. Some lasers, such as the ruby laser, use solids to generate energy. The neodymium laser is the current choice for lasers used in cutting and welding.

1. Bright, silvery, rare-earth metal element found in the minerals monazite and bastnaesite

2. Used for coloring glass and for doping glass lasers

3. Abbreviated Nd: YAG (neodymium: yellow-amber-green)

4. Capable of power densities greater than 10 billion (10,000,000,000) watts per square inch

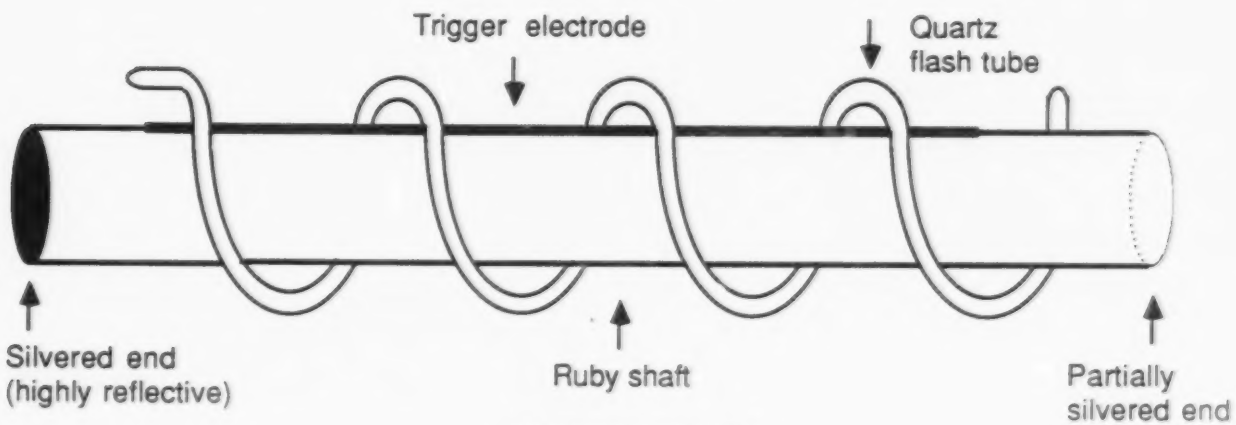
B. Gases are commonly used as the lasing medium. CO_2 has been the high-power laser workhorse of industry.

III. Ruby laser construction

A. Consists of a long ruby rod with mirrored ends

1. At one end, the mirror is totally reflective.

2. The output end's mirror is only partially reflective.



Ruby laser construction

B. Tube is normally surrounded by a powerful flash lamp such as a quartz or xenon strobe light.

C. Stimulated emission process

1. When the strobe light is triggered, its brilliant flash drives the electrons of the chromium atoms into the excited state.

2. When more of the atoms are in the excited state than in the low state, the population inversion has taken place.

3. As atoms return to the low state (electrons drop to their normal energy level), energy gained is given off in the form of photons of light.

D. Photon emission

1. An excited atom struck by one of these photons gives off two photons as it returns to the low state. One photon gives off the energy it gained from the lamp, while the other is the original photon that struck the excited atom.

2. These two photons are not emitted randomly but emerge at the same frequency and phase.

3. As they travel through the tube to the reflective end, they each strike other atoms, creating additional pairs of photons until they strike the reflective end.

4. This speed-of-light action bounces from one end of the tube to the other until it breaks through the reflective end as a coherent beam of light. In short, laser action occurs.

E. Energy efficiency

1. The ruby beam simply returns the energy that it gained from the flash tube; there is no energy gain in the process.

2. An efficiency of about 10% is all that is currently obtained by the ruby laser.

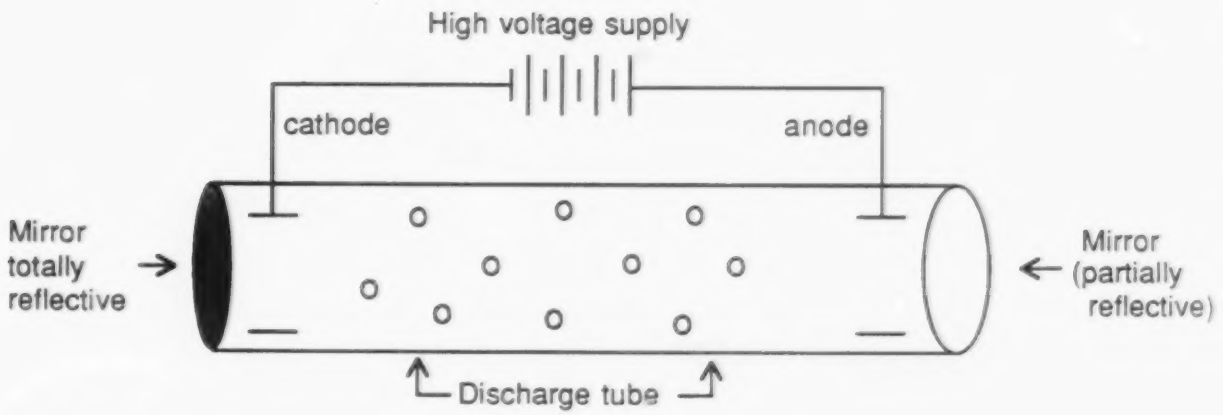
IV. The gas laser

A. Construction

1. A gas laser's construction is similar to the ruby laser in that the gas laser consists of a gas-filled tube with reflective mirrors on each end.

2. As with the ruby laser, one of the mirrors is totally reflective, while the other is partially reflective (90-95%).

3. Instead of the high-power lamp found in the ruby laser, the gas laser has an internal cathode and anode.



Gas laser construction

4. One common gas laser is the carbon dioxide (CO_2) type (see illustration).

B. Operation

1. When high-voltage pulses are applied between the cathode and anode, the electrostatic field between the electrodes and the ensuing spark causes the atoms of the gas to become excited and rise to higher energy levels.

2. As with the ruby laser, when the electrons fall back to their normal energy level, photons of light are given off.

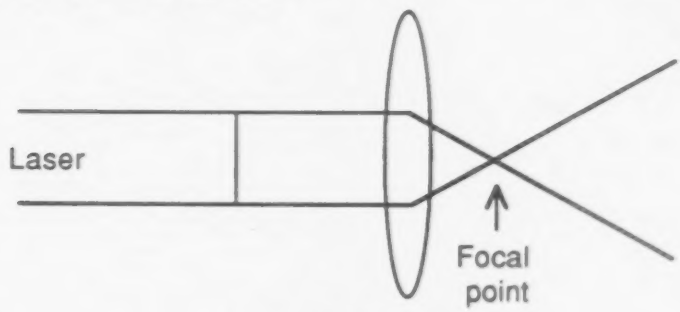
3. The rise and fall of the electrons causes photons of energy to dislodge other photons each in turn, increasing the intensity of the photon energy level.

4. They reflect back and forth from one end of the tube to the other until the energy is sufficient to pass out through the partially reflective mirror end (lasing).

5. High-power laser gasses become intensely hot; some form of cooling must be integrated into the system.

C. Focusing the laser

1. If the laser is to be used for high-power applications such as welding, cutting or drilling, the beam must be focused.



Focus of a laser beam

2. This focusing is normally accomplished with a focusing lens installed between the laser tube output and the workpiece (see illustration).

3. Since the laser is monochromatic and coherent, it can be focused to a single point.

4. The power to the workpiece can be controlled by pulsing the laser on and off at a high frequency. This on-and-off pulsing is called modulation.

D. Laser use vs. conventional cutting

1. Advantages

a. When the laser is used for cutting or drilling, it actually burns a hole instead of cutting it (e.g. a drill bit).

b. The principal advantage of using a laser is that it is constant, whereas drills dull and require replacement. As they dull, the consistency of the cut becomes less and less.

c. The laser contributes to precision and a lower cost due to eliminating the step of cutting tool replacement.

2. Disadvantages

a. As long as the material to be drilled or cut requires essentially the same heat for fusion, lasers work quite well.

b. If, on the other hand, the material has different heat requirements (such as a printed circuit board), the laser setup must be made carefully to avoid burning the lower heat requirement material (i.e. fiberglass) or insufficiently melt the high heat requirement material. Research is being done to develop techniques to cope with or solve the problem.

MODULE: OPTICAL ELECTRONICS

UNIT III: LASERS AND MASERS

UNIT TEST

Select the option which answers the question or completes the statement.

___ 1. Which kind of light is composed of a single color?

a. Monochromatic
b. Coherent
c. Laser
d. Radiant
e. Ruby

___ 2. What has occurred when more electrons are in the excited state than in the normal state?

a. Nothing unusual
b. Population inversion
c. Heat excitation
d. Laser extinction
e. Diode saturation

___ 3. What was the year of the operation of the first laser?

a. 1916
b. 1950
c. 1960
d. 1970
e. 1980

___ 4. Which of the following is <u>not</u> a part of the ruby laser?

a. Mirrored end
b. Partially mirrored end
c. Flash tube
d. Ruby
e. Transparent end

___ 5. Which type of laser is used for high-power cutting or welding?

a. Solid laser
b. Transistor laser
c. Gas laser
d. PIN diode
e. Gallium arsenide

___ 6. What is the point in the electron excitation/normal level cycle that emits the photon of energy?

a. As the electron is driven to the higher level
b. As the electron drops to the normal level
c. After the electron is in the normal level
d. When the atom is struck by the external energy source
e. When the atom's nucleus is collapsed

____ 7. The Universal Product Code is used in which system?

a. Laser drilling
b. Nuclear fusion
c. Laser measurements
d. Bar code readers
e. Box tops

____ 8. Which is the most important advantage of laser cutters over mechanical cutters?

a. More powerful than conventional cutters
b. Cheaper installations
c. Not susceptible to wear
d. Can cut a variety of material types in one pass
e. Can cut straighter lines

____ 9. Which type of laser is the current choice for welding and is capable of per-square-inch densities of 10 billion watts?

a. CO_2
b. Gas
c. Neodymium
d. Ruby
e. None of the above

____ 10. Who first introduced the concept of stimulated emission, which is basic to the laser effect?

a. Isaac Asimov
b. Charles Darwin
c. Albert Einstein
d. Gordon Gould
e. Theodore Maiman

Select "a" for true statements and "b" for false ones.

____ 11. On material with different heat requirements, such as a printed circuit board, lasers are very effective.

____ 12. Lasers are used to measure distance traveled in precision machine operations.

____ 13. All material has electrons that randomly change from one energy level to another and release very small amounts of light.

____ 14. The ruby laser's tube is normally surrounded by a powerful flash lamp such as a quartz.

ANSWERS TO UNIT TEST (J7)

1. a
2. b
3. c
4. e
5. c
6. b
7. d
8. c
9. c
10. c
11. b
12. a
13. b
14. a

MODULE: OPTICAL ELECTRONICS

UNIT IV: OPTICAL DISPLAYS

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to describe and perform basic techniques used to test and repair optical displays such as light-emitting diodes (LEDs), seven-segment displays and liquid crystal displays. This knowledge will be evidenced by satisfactory completion of the job sheet and unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student will be able to:

1.1 Discuss aspects of LED operation.

1.2 Test and replace the light-emitting diode (LED). (competency J6, JS 2.1)

2.1 Discuss seven-segment display construction and operation.

2.2 Test and replace seven-segment displays. (competency J6, JS 2.1)

MODULE: OPTICAL ELECTRONICS

UNIT IV: OPTICAL DISPLAYS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: LIGHT-EMITTING DIODE (LED)

   a. Information outline

2. Lesson 2: SEVEN-SEGMENT DISPLAY

   a. Information outline

   b. Job sheet

      JS 2.1: Test and repair optical displays

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Muchow, Kenneth, et. al. Digital Circuits. New York: Prentice-Hall, 1987.

2. Putman, Byron W. Digital Electronics: Theory, Applications and Troubleshooting. New York: Prentice-Hall, 1986.

3. Tocci, Ronald J. Digital Systems. 3rd ed. Englewood Cliffs, NJ: Prentice-Hall, 1985.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Rely heavily upon laboratory experiences to assure that the student can measure and recognize correct voltage and signals for each type of device under test.

2. Make use of manufacturer reference materials and data sheets.

B. Suggested supplemental materials

NOTE: Data sheets and reference manuals from any one or all of these manufacturers will be extremely valuable for this unit.

1. Signetics Corporation
   811 E. Arques Ave.
   P.O. Box 3409
   Sunnyvale, CA 94088-3409

2. Motorola Literature Division
   P.O. Box 20912
   Phoenix, AZ 85036

3. Panasonic Industrial Co.
   P.O. Box 1503
   Secaucus, NJ 07094

4. ECG (Substitution Manual)
   1025 Westminster Dr.
   P.O. Box 3277
   Williamsport, PA 17701

5. RCA (Substitution Manual)
   2000 Clements Bridge Rd.
   Deptford, NJ 08096-2088

6. Hewlett Packard (solid-state displays)
   6601 Winchester
   Kansas City, MO 64133

MODULE: OPTICAL ELECTRONICS

UNIT IV: OPTICAL DISPLAYS

LESSON 1: LIGHT-EMITTING DIODE (LED)

I. LED operation

A. The LED is a special kind of semiconductor diode that emits light when it is conducting.

B. LEDs are available in a variety of colors, such as red, yellow or green.

C. An LED's intensity is typically controlled by the current through it.

1. Each LED type has a maximum current rating which must not be exceeded.

2. Since the LED is commonly used in digital circuits, which have 0 or 5 V_{DC} levels, a current-limiting resistor must be added in series with the LED to keep excessive current from burning out the LED.

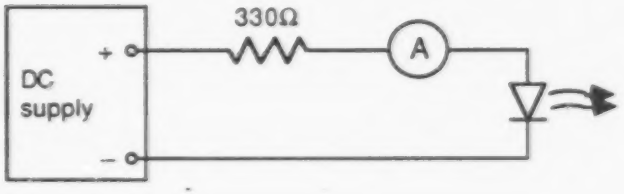
3. When conducting, the LED will drop around 2 V_{DC}, and the series resistor will drop the remainder.

II. Testing the LED

A. Identify the anode and cathode.

B. For out-of-circuit testing, use an ohmmeter on the R x 10,000 range (or any range that has a battery greater than 2V).

C. For out-of-circuit testing using a test set-up, construct a series circuit using a low voltage DC power supply, a series resistor, an ammeter and the LED.



D. In-circuit testing involves several steps.

1. The problem can be in the power supply, dropping resistor or LED.

2. Measure and verify that the power supply is proper.

3. Measure and verify that there is more than 2V across the LED.

a. If it is and the LED is off, the LED is defective.

b. If the voltage is zero, the most likely cause is the current limiting resistor. Check the resistance from the power supply to the LED. If near or at infinity, the current limiting resistor is defective.

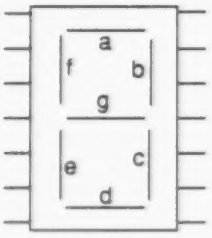
4. Remove and replace the defective component.

MODULE: OPTICAL ELECTRONICS

UNIT IV: OPTICAL DISPLAYS

LESSON 2: SEVEN-SEGMENT DISPLAY

I. Construction and operation



A. Construction

1. LED layout
2. Common anode connection--all LED anodes are connected together internally
3. Common cathode connection--all LED cathodes are connected together internally
4. Pin out

B. Operation

1. LED operation is such that each LED or segment can operate independently of the others.
2. The power requirement of each LED segment is small--typically about 40 milliwatts.
3. Current-limiting resistors must be added to each LED to restrict current flow to the correct amount--typically 330Ω.

C. Seven-segment decoder driver

1. The decoder driver converts a binary-coded hexadecimal into the appropriate driver signal combinations for the seven-segment display numbers.
2. Active high operation means that the LED segment is on when the decoder driver output is at +5 V_{DC}.
3. Active low operation means that the LED segment is on when the decoder driver output is at 0 V_{DC}.
4. Control pins are available to blank the display or to vary the display's intensity by pulsing the driver on and off.

II. Fault analysis and repair

A. Verify that the power requirements for the seven-segment display and the driver decoder are present and correct. Fix the condition if the power is incorrect.

B. Measure and record the decoder driver's input coded value.

C. Measure and verify that the decoder driver outputs and the seven-segment display inputs are the correct high and low values for the decoder driver input coded value.

1. Connect the lamp test pin to low; if there is proper operation, all segments will come on.
2. Replace the decoder driver with a known good one if the values are not correct.

3. If the inputs to the seven-segment display are correct and the display is not, replace the display with a known good one.

D. For out-of-circuit testing of the seven-segment display, use an ohmmeter (usually on the R x 10,000 range) to test each of the LEDs one at a time.

1. The ohmmeter range used must have a battery voltage in excess of 2V to exceed the diode break-over potential of the LED.

2. Each seven-segment display is unique. Refer to the manufacturer's product literature for correct pinouts.

E. Normally, the decoder driver cannot be tested out-of-circuit without specialized testing equipment (rarely available in a repair facility).

TEST AND REPAIR OPTICAL DISPLAYS

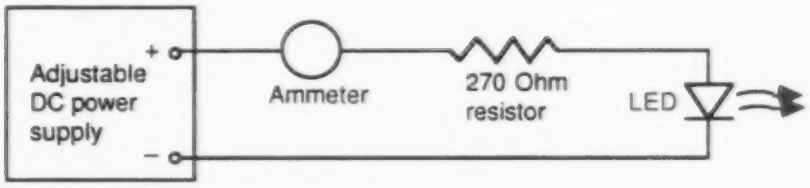
NOTE: This exercise tests and evaluates the condition of both an LED and a seven-segment display. Refer to the manufacturer's literature for pin outs, current limits and voltages.

Equipment:

Multimeter with the ohmmeter function's battery potential of more than 2V (e.g. Simpson 260)
Variable power supply, at least $2V_{DC}$
Resistors: 270Ω, 1/2 watt; 7 resistors of a value determined by the seven-segment display
LED
Seven-segment display
7447 seven-segment decoder driver
DIP switches, 4
Manufacturer's literature for the LED and seven-segment display

Procedure:	Evaluation 3	2	1	N
1. Test the LED by applying a diode test to the LED anode and cathode. Record high and low resistance values in the space below.	—	—	—	—
High reading: _____				
Low reading: _____				
2. Is the LED good? (yes/no)	—	—	—	—
3. Refer to the manufacturer's literature for the seven-segment display provided. In the space below, sketch the internal schematic diagram of the display.	—	—	—	—
4. Apply a diode test to each of the seven segments using the ohmmeter.	—	—	—	—
5. Did each of the segments test as a diode?	—	—	—	—
6. What is the condition of the display?	—	—	—	—

7. Construct the following circuit.



8. After referring to the manufacturer's literature, record the maximum current for the LED.

$I_{maximum}$ _____ mA

9. Slowly increase the output of the DC supply until the first indication of a glow from the LED is observed. Record the current.

I = _____ mA

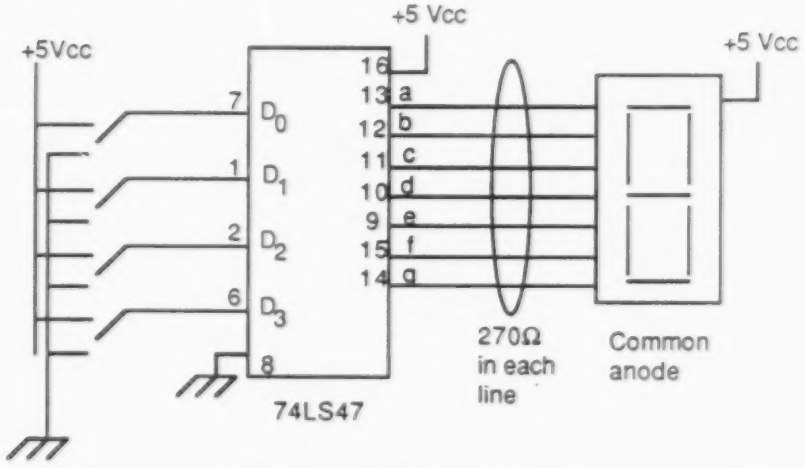
10. Increase the DC supply output to the maximum current rating of the LED. Did the LED increase its output as the current increased? (yes/no)

11. Using the following formula, calculate the value of current limiting resistor required for the seven-segment display.

$$R_{limiting} = \frac{5\ V_{cc} - E\ drop\ of\ segment\ (usually\ about\ 1.7V)}{I_{max}\ for\ one\ segment\ of\ the\ display}$$

R limiting = _____ Ω

12. Construct the circuit below.



Seven-segment display circuit

13. Connect the lamp test pin to ground. All segments should come on; verify that they do.

14. In turn, apply BCD values of 0-9 and verify that the seven-segment display followed the inputs by displaying each number (0-9). Record each indication of the display. — — — —

BCD input	Seven-segment display
0000	
0001	
0010	
0011	
0100	
0101	
0110	
0111	
1000	
1001	

15. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competency J6: Test and repair optical displays.

MODULE: OPTICAL ELECTRONICS

UNIT IV: OPTICAL DISPLAYS

UNIT TEST

Select the option which answers the question or completes the statement.

___ 1. Which of the following is the most appropriate reference to find out the pin configuration of a seven-segment display?

a. Textbook
b. Manufacturer's literature
c. Schematic diagram
d. Underside of the display
e. Marked at each pin

___ 2. At least how many volts must the ohmmeter battery be to test an LED as a diode?

a. .7 V_{DC}
b. 1.2 V_{DC}
c. 2 V_{DC}
d. 4 V_{DC}
e. 6.3 V_{DC}

___ 3. You note that a single LED does not glow. Which of the following is <u>not</u> an appropriate test?

a. Power supply check
b. Driver input
c. Driver output
d. RAM R/W line
e. Data line DO

___ 4. The "g" segment of a seven-segment display glows when the numbers 3, 5, 6, 8 or 9 are displayed but does not glow when the number 2 is displayed. What is the most likely problem?

a. Decoder driver
b. There is no problem
c. An open "g" bar
d. Current limiting resistor
e. Faulty microprocessor

___ 5. What is the best approach to verify that a suspected defective decoder driver is truly bad?

a. Connect it into a decoder driver tester.
b. Remove and replace it with a known good one.
c. Jump around the decoder driver.
d. Replace the seven-segment display.
e. Check the power at pin 14.

___ 6. A test circuit consisting of a DC power supply, an ammeter, a resistor and the LED is set up all in series. Increasing the DC power supply output does not cause the LED to glow or the ammeter to register current. What is the most likely problem?

a. The LED is shorted.
b. This is normal operation.
c. This is not a correct set-up to test an LED.
d. The LED is open.
e. None of the above

Identify true statements with an "a" and false ones with a "b."

___ 7. An LED's intensity is controlled by the current through it.

___ 8. The control pins of the decoder driver can be used to vary the intensity of the seven-segment display.

ANSWERS TO UNIT TEST (J6)

1. b
2. c
3. d
4. a
5. b
6. d
7. a
8. a

MODULE: OPTICAL ELECTRONICS

UNIT V: OPTICAL ENCODERS

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to explain the terms, applications and operation of basic optical encoders found in various situations throughout the electronic industry. This knowledge will be evidenced by achieving the specified score on the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student will be able to:

1.1 Define the terms associated with optical encoders.

1.2 Identify advantages of optical encoders.

1.3 Describe construction and use of the incremental encoder.

2.1 Describe applications and construction of absolute encoders.

2.2 Discuss the use of absolute encoders for multiple revolutions. (competency J8)

MODULE: OPTICAL ELECTRONICS

UNIT V: OPTICAL ENCODERS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: INCREMENTAL ENCODERS

   a. Information outline

   b. Assignment sheet

      AS 1.1: Incremental encoders

   c. Answers to assignment sheet

2. Lesson 2: ABSOLUTE ENCODERS

   a. Information outline

   b. Assignment sheet

      AS 2.1: Absolute encoders

   c. Answers to assignment sheet

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Harrington, John. Automated Process Control Electronics. Albany, NY: Delmar, 1989.

2. Hoekstra, Robert L. Robotics and Automated Systems. Cincinnati, OH: South Western Publishing Co., 1986.

3. McDonald, Anthony, and H. Lowe. Feedback and Control Systems. Reston, VA: Reston Publishing Co., Inc., 1981.

4. Seippel, Robert G. Industrial Electricity and Electronics. Reston, VA: Reston Publishing Co., Inc., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Optical encoders can be found in virtually every piece of electronic equipment that has moving parts. In an office copier, for example, the paper position is controlled by the optical encoder during the copy process. Robotic arm position is often determined by optical encoders. Other applications include level control, tachometers and linear movement measurement.

2. Show many examples of optical encoder applications.

3. A review of optical principles is recommended.

B. Suggested student activities

1. Study sections of several texts that use applications of optical encoders.

MODULE: OPTICAL ELECTRONICS

UNIT V: OPTICAL ENCODERS

LESSON 1: INCREMENTAL ENCODERS

I. Terms and definitions

A. Precision--encoder repeatability. The measurement is not necessarily close to the correct value. For example, an optical encoder can report with a great deal of repeatability that a certain shaft position is at 186°, when in fact the shaft position might be something entirely different--perhaps 180°. All subsequent position reports will be within .01° of this initial report.

B. Accuracy--closeness to the truth or absolute value. For example, the encoder might report that a certain shaft position is 179°, when in fact the shaft is at 180°. In this situation, the reported value is close to the actual value, even though subsequent reporting of that position can vary by as much as 1° from the first report.

C. Ambiguity--the ± uncertainty that is always associated with a digital system. If the optical encoder is a four-digit encoder, the value reported will have a range of possible values that are plus-or-minus one count of the least significant digit.

Example: For 1011, the range of possible values could be 1010-1100.

D. Gray code--used in optical encoders because only one digit changes as the encoder output is changed. (See absolute encoders in the second lesson for an example.) As an unweighted code, its digital code does not have a relationship to the binary system. The Gray code must be converted to binary before use.

E. Disk or rotary encoder--used to convert rotary motion into a binary-coded set of values that represent the rotation of a motor or gear's shaft

F. Linear encoders--used to convert linear position into a binary representation of the position

G. Incremental encoder--reports the rotation or linear motion as a series of steps or pulses. There is no code involved--simply a series of on-off pulses that a computer counts.

Example: 5000 counts or pulses per revolution

H. Absolute encoder--a multi-track disk that produces a coded value for each position of the rotation of the disk. Unlike the incremental encoder, if power is lost during use, the system can read the absolute position of the disk upon restoration of power. This system has a track for each binary-coded digit.

II. Advantages of optical encoders over mechanical counterparts

A. Lower cost

1. Modern technology is related to the ability to control equipment precisely with the computer. For any system to be acceptable, it must have a long use life.

2. The equipment must retain its original accuracy.

3. The reduction of mechanical parts is possible by using optical encoders to identify motion and position of equipment.

4. Not subject to breakdown or repeated service interruptions during the service life

5. No mechanical parts to wear on an optical encoder

B. Computer compatibility

1. A common life cycle for an optic sensor is in excess of 5,000,000 operations.

2. The output of the optical encoder is a series of logic ones and zeros that are caused by the presence or the absence of a light beam on a optic sensor.

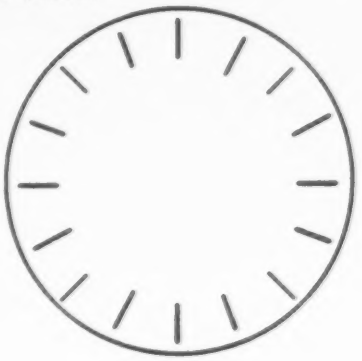
III. Incremental encoder (most elementary kind of optical encoder)

A. Construction

1. This device is a disk that has a series of slots around the perimeter. These slots interrupt and pass a beam of light as the disk rotates.

2. Each light beam that is passed becomes an electrical pulse representing a single logic 1.

3. A disk that has 360 slots would give 360 pulses per revolution for a resolution of 1°.



Incremental encoder

4. If additional resolution is needed, the number of slots must be increased.

$$\text{Number of slots} = \frac{360 \text{ degrees}}{\text{degrees of resolution per step}}$$

5. Current technology has a practical separation limit between slots of .010-.005". (As increased resolution is required, a point will be reached when the size of the disk must be increased to permit the additional numbers of slots.)

B. Use as an encoder

1. The incremental encoder can have a zero reference marker for a "home base", or there might be an external mechanical home for the system.

2. Since the operation of the system results in an output of a series of logical pulses, position recognition is not a function of the disk. Position is determined by software in the interconnected computer based on the number of pulses counted.

Example: Consider a command to a robot shoulder to raise 20°. If the encoder has 10 pulses per degree (a resolution of .1° per pulse), the shoulder motor would be commanded to drive until the feedback from the optical disk encoder reached a count of 200 (20° x 10 pulses per degree).

C. Use as a tachometer

1. Rotation of the disk produces a series of pulses.

2. Rotation speed is directly related to the rate of the pulse string from the optical encoder.

3. The actual rpm determination is accomplished by the software of the system if a computer is used. The formula for such a conversion follows.

$$\text{rpm} = \frac{\text{Pulses per second}}{\text{Pulses per revolution}} \times 60$$

INCREMENTAL ENCODERS

1. Show how many slots in an optical disk are required for each of the following resolutions.

   a. 1° per pulse _____

   b. 6° per pulse _____

   c. .5° per pulse _____

   d. .1° per pulse _____

2. If an extremely precise control of the rotation of an optical encoder is required, for example .0001° per slot, what effect will this have on the construction of the disk?

3. How many slots or steps will be required of an optical encoder that has a precision of .05° per step?

4. A linear encoder is being used as a tachometer. The encoder has 720 pulses per revolution. You observe a pulse rate of 1500 pulses per second. What is the rpm of the shaft?

5. An encoder's precision of .2° per pulse is used in the elbow of a robot. How many pulses will be counted with a command to move the elbow 27°?

6. An encoder has a precision of .05° per pulse. What will be the pulse rate (per second) if the disk is being driven at 350 rpm?

ANSWERS TO AS 1.1

1. a. 360 slots
   b. 60 slots
   c. 720 slots
   d. 3600 slots

2. Will make the disk larger

3. 7200

4. 125 rpm

5. 135 pulses

6. 42,000 pulses per second

MODULE: OPTICAL ELECTRONICS

UNIT V: OPTICAL ENCODERS

LESSON 2: ABSOLUTE ENCODERS

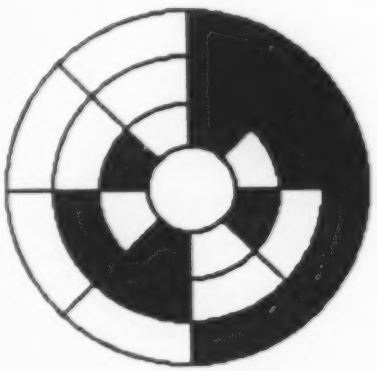
I. Application and construction

A. Provide a unique coded value for each rotation position.

B. Construction similar to a disk with several tracks

1. Each track represents a binary digit with the innermost ring representing the most significant bit and the outer, the least.

2. A series of optical sensors, one for each ring, records the position as a series of high or low pulses, depending on which light beam is passed or blocked.



Three-bit optical encoder disk

C. Recording limitations

1. The three-bit optical encoder can record only eight discrete positions of rotation.

2. A four-bit encoder could record 16; a five-bit, 32; and so on.

3. The maximum number of divisions possible for one revolution of the absolute encoder is 2 raised to the power of the number of bits or rings.

Maximum divisions per revolution = 2^n
(n represents the number of decoder rings or bits)

II. Multiple revolutions

A. BCD limitations

1. In a BCD system, two or more digits frequently change position at the same time. When applied to a mechanical system, this multiple digit change requires extreme precision and attention to ensure that alignment is correct. Without such precision and alignment, coded errors will occur.

2. The Gray code is used to prevent errors and to reduce the degree of precision required of the construction.

B. Gray code

1. The Gray code is an unweighted code that produces only one digit change per increment. This reduces the probability of positional errors due to misreading the position of the disk.

2. See the comparison between BCD and Gray codes to the right.

a. Note that there is no relationship between the two systems beyond the numbers zero and one.

b. Unlike the BCD system, the Gray code has only one digit per increment changing.

3. The encoder usually converts the Gray code into BCD so the computer can recognize it.

BCD	Gray
0000	0000
0001	0001
0010	0011
0011	0010
0100	0110
0101	0111
0110	0101
0111	0100
1000	1100
1001	1101
1010	1111
1011	1110
1100	1010
1101	1011
1110	1001
1111	1000

C. Location tracking

1. As long as the encoder never turns more than one revolution, the absolute position is maintained.

2. If, however, the encoder is rotated more than one turn, additional considerations must be made. An example might be on a CNC (computer-controlled) system or a robot arm. During the total movement from one position to another, the absolute encoder might make several hundred rotations.

3. A second sub-routine normally keeps track of the number of rotations within the computer controller. In this manner, the command might be to move the table or the arm from position A to position B.

4. The coarse movement might be a certain number of revolutions, and the fine position movement might be the final rotation of the encoder to an absolute position.

5. If power is lost after more than one revolution of the absolute encoder, the system has no way of knowing where home is and the system will have to be restarted at home position.

D. Multiple gear train encoders

1. Some robot systems use a precision gear train that drives two or more absolute position encoders. This system permits the computer to maintain an absolute knowledge of the arm or other element at all times.

2. If power is lost or the system is shut down, there is no need to initialize the robot at its home position as all positions within the operating envelope have individually coded locations recognizable by the computer.

ABSOLUTE ENCODERS

1. What is the primary difference between the incremental and the absolute encoder?

2. How many tracks will be required on an absolute encoder if the rotation is to be divided into 1024 divisions?

3. Why is the Gray code used instead of the BCD for the absolute encoder?

4. If the Gray code is 0110, what is the corresponding BCD value?

5. If an absolute encoder with a single disk has made 5.72 revolutions and power is lost, how will the system know exactly where it is when power is restored?

6. What improvement in the absolute encoder could be suggested so that if power is lost or the system is shut down, the system won't need to be re-initialized upon turn-on?

ANSWERS TO AS 2.1

1. Multiple tracks to indicate a coded absolute position
2. 10
3. Only one bit at a time changes.
4. 0100
5. The position is coded on the disk and directly read as a coded value.
6. Add multiple-gear trains and encoders to keep track of the number of revolutions the encoder has made.

MODULE: OPTICAL ELECTRONICS

UNIT V: OPTICAL ENCODERS

UNIT TEST

Select the option which answers the question or completes the statement.

___ 1. Which term describes the degree of repeatability of a measurement?

a. Precision
b. Accuracy
c. Ambiguity
d. Tolerance
e. Reliability

___ 2. Which of the following codes is used in decoders because it changes only one digit at a time?

a. Excess 3
b. BCD
c. Gray
d. Octal
e. Hex

___ 3. Which of the following devices has an output of a series of pulses as rotation occurs?

a. Absolute encoder
b. Linear accelerator
c. Slotted encoder
d. Incremental encoder
e. Linear encoder

___ 4. What is the resolution of a disk encoder that has 720 slots?

a. ±1°
b. ±.5°
c. ±.1°
d. ±.05°
e. ±.01°

___ 5. What is the number of degrees of resolution for an absolute encoder that has four tracks?

a. ±45
b. ±30
c. ±22.5
d. ±16
e. ±8

___ 6. Which of the following decoders would most likely be used as a tachometer?

a. Incremental encoder
b. Absolute encoder
c. Magnetic encoder
d. Linear encoder
e. Linear accelerometer

___ 7. A robot arm is to move 30°. The encoder has a resolution of .2° per pulse. How many pulses must occur for the desired motion?

a. 30
b. 60
c. 120
d. 150
e. 180

___ 8. Optic sensors commonly last for how many operations?

a. 1,500-2,000
b. 5,000-6,000
c. 10,000-12,000
d. 2,000,000-3,000,000
e. At least 5,000,000

___ 9. Which is <u>not</u> an advantage optical encoders have over their mechanical counterparts?

a. Long manufacturing use life
b. Retains original accuracy
c. Lower cost
d. Computer compatibility
e. Affected little by power surges

___ 10. What must be considered if normal operation will cause the absolute encoder to turn more than one revolution?

a. Multiple revolution use is not permitted.
b. Keep track of the number of revolutions.
c. Add a gear train to keep the revolution to one.
d. Use multiple absolute encoders in parallel.
e. Use a linear encoder instead of the absolute encoder.

ANSWERS TO UNIT TEST (J8)

1. a
2. c
3. d
4. b
5. c
6. a
7. d
8. e
9. e
10. b